Title:
# Mars Exploration Rover Landing Site Hectometer Slopes

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Abstract:
The Mars Exploration Rover (MER) airbag landing system imposes a maximum slope of 5 degrees over 100 m length-scales. This limit avoids dangerous changes in elevation over the horizontal travel distance of the lander on its parachute between the time of the last radar altimeter detection of the surface and the time the retro-rockets fire and the bridle to the airbags is cut. Stereo imagery from the MGS MOC can provide information at this length scale, but MOC stereo coverage is sparse, even when targeted to MER landing sites. Additionally, MGS spacecraft stability issues affect the DEMs at precisely the hectometric length-scale$^{1}$. The MOLA instrument provides global coverage pulse-width measurements$^{2}$ over a single MOLA-pulse footprint, which is about 100 m in diameter. However, the pulse spread only provides an upper bound on the 100 m slope.

We chose another approach. We sample the inter-pulse root-mean-square (RMS) height deviations for MOLA track segments restricted to pixels of 0.1 deg latitude by 0.1 deg longitude. Then, under the assumption of self-affine topography, we determine the scale-dependence of the RMS deviations and extrapolate that behavior over the range of 300 m to 1.2 km downward to the 100 m scale. Shepard et al.$^{3}$ clearly summarize the statistical properties of the RMS deviation (noting that it also goes by the name structure function, variogram or Allan deviation), and we follow their nomenclature. The RMS deviation is a useful measure in that it can be directly converted to RMS-slope for a given length-scale.

We map the results of this self-affine extrapolation method for each of the proposed MER landing sites as well as Viking Lander 1 (VL1) and Pathfiner (MPF). In order of decreasing average hectometer RMS-slopes, Melas (about 4.5 degrees) $>$ Elysium EP80 $>$ Gusev $>$ MPF $>$ Elysium EP78 $>$ VL1 $>$ Athabasca $>$ Isidis $>$ Hematite (about 1 degree). We also map the scaling parameter (Hurst exponent); its behavior in the MER landing site regions is interesting in how it ties together the regional behavior of kilometer slopes (directly measured with MOLA) with the decameter and meter slopes (locally derived from stereo image analysis or radar scattering).

$^{1}$Kirk, R. L., E. Howington-Kraus, and B. A. Archinal, {\it Int. Arch. Photogramm. Remote Sens., XXVIII(B4)}, 476 (CD-ROM), 2001; Kirk, R. L., E. Howington-Kraus, and B. A. Archinal, {\it Lunar Planet Sci., XXXIII}, abs 1988, 2002.

$^{2}$Garvin, J. B., and J. J. Frawley, {\it Lunar Planet. Sci., XXXI}, abs 1884, 2000.

$^{3}$Shepard, M. K., R. A. Brackett, and R. E. Arvidson, {\it J. Geophys. Res.}, {\it 100}, 11709-11718, 1995.; Shepard, M. K., {\it et al.}, {\it J. Geophys. Res.}, {\it 106}, 32777-32796, 2001.